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ABSTRACT

The course of study represents the fifth of six modules in advanced crop and soil science and introduces the agriculture student to chemical features of the soil. Upon completing the four day lesson, the student will be able to: (1) list macro- and micro-nutrients, (2) define pH and its effect on plants, (3) outline Cation Exchange of the soil, (4) understand fertilizer production, (5) recognize plants exhibiting nutrient deficiencies, (6) interpret information on a fertilizer tag or bag. The course outline suggests teaching procedures, behavioral objectives, teaching aids and references, problems, a summary, and evaluation. Following the lesson plan, pages are coded for use as handouts and overhead transparencies. A materials source list for the complete soil module is included. (MW)

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CHEMICAL FEATURES OF SOIL

Agricultural Education, College of Education
Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

In Cooperation With

Agricultural Education Service, Division of Vocational Education
State Department of Education, Richmond, VA 23216
Prepared by Larry E. Miller

Publication AP-13
1974

ED 098290

ADVANCED CROP AND SOIL SCIENCE
A COURSE OF STUDY

Prepared by
Larry E. Miller

Agricultural Education Program
Division of Vocational and Technical Education
College of Education
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1974

ACKNOWLEDGEMENTS

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A Virginia Polytechnic Institute and State University
Extension Division
Education Field Service Publication

How to Use This Book

This course of study is divided into six modules, as enumerated in the index. Each lesson plan contains the title of the:

course,
module,
a suggested time allotment,
a suggested teaching procedure,
objectives of the lesson,
example introduction techniques,
suggested references and teaching aids,
problems,
summary.
and example evaluatory statements.

Space is provided for individual evaluation.

Modules are lettered consecutively, with numbered pages within each module. A small letter following the number denotes its position within the numbered sequence. Following the lesson plans, pages are also denoted with the letter "H", recommended as a handout; and the letter "T", recommended as an overhead transparency.

Some instructors may find it of greater convenience to assemble a "slide-bank" of these teaching aids.

Materials Source List
(Soil Module Only)

SELECTED REFERENCES:

Books:

*Profitable Soil Management, Knuti, Korpi and Hide, Prentice-Hall, Englewood Cliffs, New Jersey 07632, 1969, $8.36.
*Introductory Soils, Berger, K.C., 1965, Macmillan Company, 866 3rd. Avenue, New York, N.Y. 10022, $8.50.
*Soils: An Introduction to Soils and Plant Growth, 2nd Ed., Donahue, Prentice-Hall, 1964, $9.75.
*Approved Practices in Soil Conservation, Foster, Interstate, 1964, $3.80.
*Our Soils and Their Management, Donahue, Interstate, $5.00.
**Farm Soils, Worthen and Aldrich, Wiley & Sons.
**Fundamentals of Soil Science, Millar, Turk.
**The Nature and Properties of Soils, Buckman and Brady, Macmillan, 1969, $10.95.
**Soils and Soil Fertility, Thompson, McGraw-Hill.
**Soil Fertility and Fertilizers, Tisdale and Nelson, Macmillan, 2nd Ed. 1966, $12.95.
**Soil Use and Improvement, Stallings, J.H., Prentice-Hall, $8.36.
**Soil Management for Conservation and Production, Cook, J.W. Wiley and Sons, 1962.
**Soil Physics, Kohnke, McGraw-Hill.
**Using Commercial Fertilizers, McVicker, Interstate, 1961, $4.00 Good.
**Our Natural Resources, McNall, Interstate, 1964.
**Soil Science Simplified, Kohnke & Helmut, Bolt, 1962. Good.
**Soil Conservation, Stallings, Prentice-Hall, 1957, $11.75.
*Experiments in Soil Science, California State Polytechnic College, San Luis Obispo, California 93401, $4.00.
**Factors of Soil Formation, Jenny.

Bulletins:

*"Soil Judging in Indiana" Purdue Mimeo I.D. 72.
*"Soil Color" Voc. Ag. Service, 434 Mumford Hall, Urbana, Illinois 61801
*"Soil Texture" - Illinois V.A.S.
**"Teaching Soil and Water Conservation, A Classroom and Field Guide" PA 341 U.S.D.A.
**"Water Intake by Soil Experiements for High School Students" Misc. Publ. No. 925, U.S.D.A.
**Soils Yearbook, U.S.D.A.
**Land Capability Classification, Agriculture Handbook No. 210, U.S.D.A.
**Soil Survey Manual, U.S.D.A."
*"Sampling the Soil", National Fertilizer Association, Washington, D.C.
*"Soil Testing" Purdue University Extension Circular, 488.
**"The Fertilizer Handbook:, National Plant Food Institute (NPFI) 1700 K. Street N.W., Washington, D.C. 20006

*Student Reference
**Instructor or Classroom reference

*"Our Land and Its Care", N.P.F.I.
*"What is Fertilizer?" N.P.F.I.
*"How to Take a Soil Sample", N.P.F.I. (Leaflets** and Poster*)
*"Lime Means More Money for You", N.P.F.I. (leaflets** and Poster*)
**"How Soil pH Affects Plant Food Availability", N.P.F.I. (Poster)
**"Hunger Signs in Crops", Illinois V.A.S., VAS 4011a
*"Soil and Plant Tissue Tests", Purdue Station Bulletin 635
*"Soil Science Simplified", Kohnke, Published by Author

Films:

"The Depth of Our Roots", New Holland, C-18 Min.
"Making the Most of a Miracle" (Plant Nutrition), N.P.F.I.
"The Big Test" (Importance of Soil Testing), N.P.F.I.
"What's in the Bag" (Fertilizer) N.P.F.I.

Film Bulletin:

"Films to Tell the Soil and Water Conservation Story" 1970 Soil Conservation Service, Film Library, Rm. 503-134 So. 12th St., Lincoln, Nebraska 68508.

Film Strips:

"Soil Color" Vo-Ag. Service, 434 Mumford Hall, Urbana, Illinois.
"Soil Structure" Vo-Ag. Service, Illinois.
"How and Why Soils Differ", Vo-Ag. Service, Illinois.

Slides:

"How to Take a Soil Sample", N.P.F.I.
"Soils, Plant Nutrition and Fertilizers", N.P.F.I.
"Deficiency Symptoms" (Choice by crop, 25¢ ea.) N.P.F.I. (Send for Catalog.)
"Soil Profile Slides", 16 slides, $6.00. (Send for Catalog.)

Periodicals:

"Plant Food Review", N.P.F.I. (Free to Schools.)

TEACHER'S CURRICULUM GUIDES FOR SOILS

"Understanding the Nature and Importance of Soil", AP-1, C. E. Richard, VPI & SU, Blacksburg.

"Preparing the Soil for Planting", AP-3, C. E. Richard, VPI & SU, Blacksburg.

"Developing a Soil and Water Conservation Plan", AP-4, C. E. Richard, VPI & SU, Blacksburg.

"Testing Soils", AP-8, C. E. Richard, VPI & SU, Blacksburg.

"Determining Land Capability Classes", AP-2, C. E. Richard, VPI & SU, Blacksburg.

Extension Division Bulletins, VPI & SU,
Blacksburg, Virginia 24061.

NO.	PUBLICATION
342	"No-tillage Corn - Current Virginia Recommendations"
429	"Soil Fertility Guides for the Piedmont"
97	"Agronomy Handbook"
136	"How Soil Reaction Affects the Supply of Plant Nutrients"
297	"Soil Fertility Guides - for the Coastal Plains Region of Virginia"
299	"Soil Fertility Guides - for the Appalachian Region of Virginia"
684	"Liming for Efficient Crop Production"
36	"Your Fertilizer Use and Crop Record"
106	"Lime Use Guides - for the Coastal Plains Region of Virginia"
107	"Lime Use Guides - for the Appalachian Region of Virginia"
108	"Lime Use Guides - for the Piedmont Region of Virginia"
405	"Lime for Acid Soils"
34	"Soil and Water Conservation Record Book"
CS48	"Soil Sterilization"
47	"Know Your Soils, Unit 2, Major Soil Differences"
23	"The Story of Land"
228	"Working Together for a Liveable Land"

USDA Bulletins (1 each of 100 publications, free)
Publications Division, Office of Information,
U.S.D.A., Washington, D.C. 20250. *FOR SALE ONLY

NO.	PUBLICATION	PRICE
AH210	Land Capability Classification. 1961	.15¢
AH18	Soil Survey Manual. 1951.	$3.50*
AB320	Know the Soil You Build On. 1967.	--
L539	Land Forming, A Means of Controlling Surface Water on Level Fields. 1967	.05*
L512	Mulch Tillage in the Southeast	--
YB1957	Soil (Yearbook)	$4.00*
L307	How Much Fertilizer Shall I Use? 1963.	--
G89	Selecting Fertilizers for Lawns and Gardens. 1971.	--
TITLE	Superphosphate: Its History, Chemistry, and Manufacture. 1964.	$3.25*

*"Maintaining Organic Matter in Soils" VAS, Illinois
*"Soil Structure" VAS, Illinois

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*Student Reference
**Instructor or Classroom Reference

TEACHING AIDS:

1. Samples of Soil separates, Purdue Agronomy Club
   Life Science Building
   Purdue University
   Lafayette, Indiana 47907

2. Soil Profiles
   Information and directions necessary to make soil profiles.

3. Land Capability Maps - Local S.C.S. Office.

4. Soil Auger: Nasco, price range $4.79 - $13.50.

5. Tissue Test Kit V.A.S. $4.00/kit.

6. Transparencies.

7. Samples of soil structure.

PREPARING FOR SOILS MODULE

Proper preparation, as in all things, is one of the best assurances of success. Therefore, it is imperative that prior planning be completed before teaching each lesson.

Plans should be made several weeks or months preceding the need for much of the material. Films should be booked as soon as possible to assure their arrival when needed. This will necessitate careful thought in the preparation of your teaching calendar for this module. An inventory of present equipment should yield information necessary to securing needed teaching aids, equipment, and replenishing supplies.

Many other teaching aids can be compiled on shorter notice. Handouts and overhead transparencies can be supplied on rather short notice in most schools. Adjustments will be necessary according to the instructor's and school's clerical assistance in this area.

Short range planning varies considerably with individual instructor's compentencies in the teaching area and with previous teaching experience. One may generalize, however, and conclude from good teaching methods, that films should be previewed; experiments and demonstrations "pre-run". Subject matter should be reviewed, and adapted and updated lesson plans will be of benefit for each lesson.

The author has attempted to exclude materials that were presumably taught in previous vo-ag. offerings. It will be necessary for each instructor to discern if a review of previous material is necessary. The author has attempted to provide several teaching techniques for each lesson. It is not assumed that all would be used within the time allotment, but that you may have as many alternatives as possible from which to select.

Soil Module Time Allotment
Allotted days: 15 (at 55 minutes period per day)

Lesson		Minutes
I:	What is soil?	110
II:	Physical Features of Soil	110
III:	Biological Features of Soil	110
IV:	Soil Water	165
V:	Chemical Features of Soil	220
VI:	Soil Erosion	110
	TOTAL (15-55 min. days)	825

Course: Advanced Crop and Soil Science

Module: Soils

Lesson V: Chemical Features of Soil

Suggested teaching time: 4 days

Suggested teaching procedure:

1. Introduce lesson by relating objectives and motivational statements and/or using other teaching aids to stimulate interest.

2. Make assignment and supervise study period.

3. Discuss results using teaching aids:

   a) Show "Soil Reaction and Plant Nutrient Availability" to illustrate macro and micro-nutrients and add additional elements. Supplement with films, bulletins and demonstrations.
   b) Show transparencies "pH Scale", "pH Requirements of Crops", and "Soil Reaction and Plant Nutrient Availability" to illustrate soil pH. Supplement with posters, bulletins, and other teaching aids.
   c) Show transparencies "Root Hairs in Soil" with overlays, "Soil Solution" with overlay, "Ionic Exchange in Alkaline Soils", with overlay, and "Soil Particles and Ions" with overlay to illustrate principles. Supplement with other teaching aids. Run a soil sample test.
   d) Use transparency, "Nitrogen Fertilizer Production:, and demonstration "The Manufacture of Phospate Fertilizer" to illustrate how fertilizer is produced. Supplement with appropriate teaching aids.

   e) Use slides and bulletins to illustrate nutrient deficiencies, or live specimen if available.

   f) Use tissue test kit to test for plant deficiencies.

   g) Use transparencies, "Fertilizer Labeling" with overlays, to illustrate nomenclature of fertilizer. Demonstration, "What's in the Fertilizer Bag", would be extremely beneficial.

4. Summarize and evaluate lesson.

Objectives:

1. Students be able to list macro and micro-nutrients
2. Students be able to define pH and its effect on plants.
3. Students be able to outline Cation Exchange of the soil.
4. Students be cognizant of how fertilizer is produced.
5. Students be able to recognize plants exhibiting nutrient deficiencies.
6. Students be able to interpret information on a fertilizer tag or bag.

Introduction:

Show several slides of plants exhibiting nutrient deficiencies and ask what caused this to happen.

References:

Text: Selected reference

Slides: "Soil, Plant Nutrients, and Fertilizers, N. P. F. I.
"Deficiency Symptoms:, N.P. F. I.

Periodicals: "Plant Food Review", N. P. F. I.

Equipment: Soil Test Kit, Sudsbury or equivalent, $30.00
Tissue Test Kit, V. A. S., Illinois, $4.00

Films: "Making the Most of a Miracle", N. P. F. I.
"The Big Test", N. P. F. I.
"What's in the Bag", N. P. F. I.

Bulletins: "Experiments in Soil Science" pp 97-200 and 229-240, V. E. P.
"Sampling the Soil", National Fertilizer Assn.
"Soil Testing" Purdue, Ext. Circular 488
"The Fertilizer Handbook", N. P. F. I.
"What is Fertilizer", N. P. F. I.
"How to take a Soil Sample", N. P. F. I.
"Lime Means More Money for You", N. P. F. I.
"Hunger Signs in Crops", VAS, Illinois, 401la
"Soil and Plant Tissue Tests", Purdue Bll. 635
"Nature of Soil Acidity and Major Soil Nutrients", VAS 4005
"pH Test for Soil Acidity", VAS 4002a
"Planning a Fertilizer Program", VAS 4010a

"Testing Soil for Phosphorus", VAS 4003a
"Determining Available Phosphorus in Soils", VAS 4004b
"Our Land and Its Care", N. P. F. I.
"Soil Liming - A Key to Better Farming", VAS 4006a
"Planning the Nitrogen Program", VAS 4009a
"Recommending Potassium Fertilizers", VAS 4008a

Posters: "How to take a Soil Sample", N. P. F. I.
"Lime Means More Money for You", N. P. F. I.
"How Soil pH Affects Plant Food Availability", N. P. F. I.

Problems:

1. What nutrients are required for a plant to grow?
2. What is soil pH?
3. How do plants get nutrients from the soil?
4. How are nutrients supplied to the soil?
5. How are fertilizers produced?
6. What effect does nutrient deficiencys have upon plants?
7. How can you tell if a plant is deficient in certain nutrients?
8. What does the nomenclature on a fertilizer bag mean?

Summary:

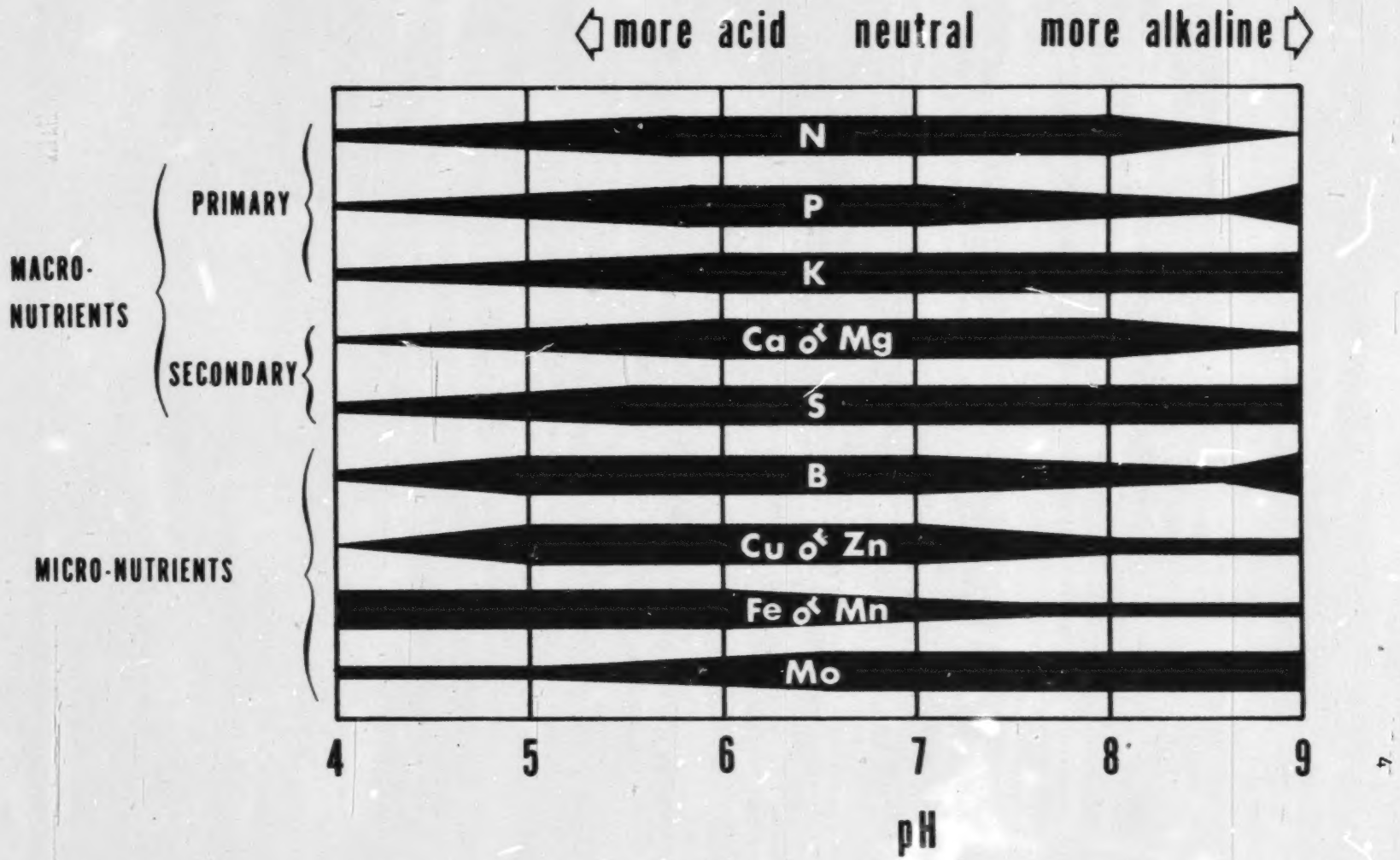
Plants and man are dependent upon the soil for their food supply. It is the farmers responsibility to produce food and he can do that best by keeping the nutrient supply of his soil at an optimum.

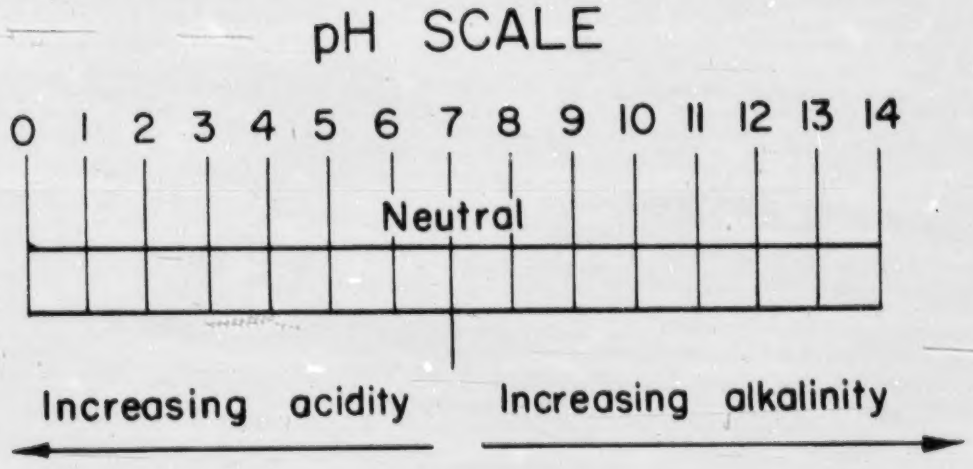
Evaluation:

A. Can the students meet the objectives of the lesson?

Student evaluation:

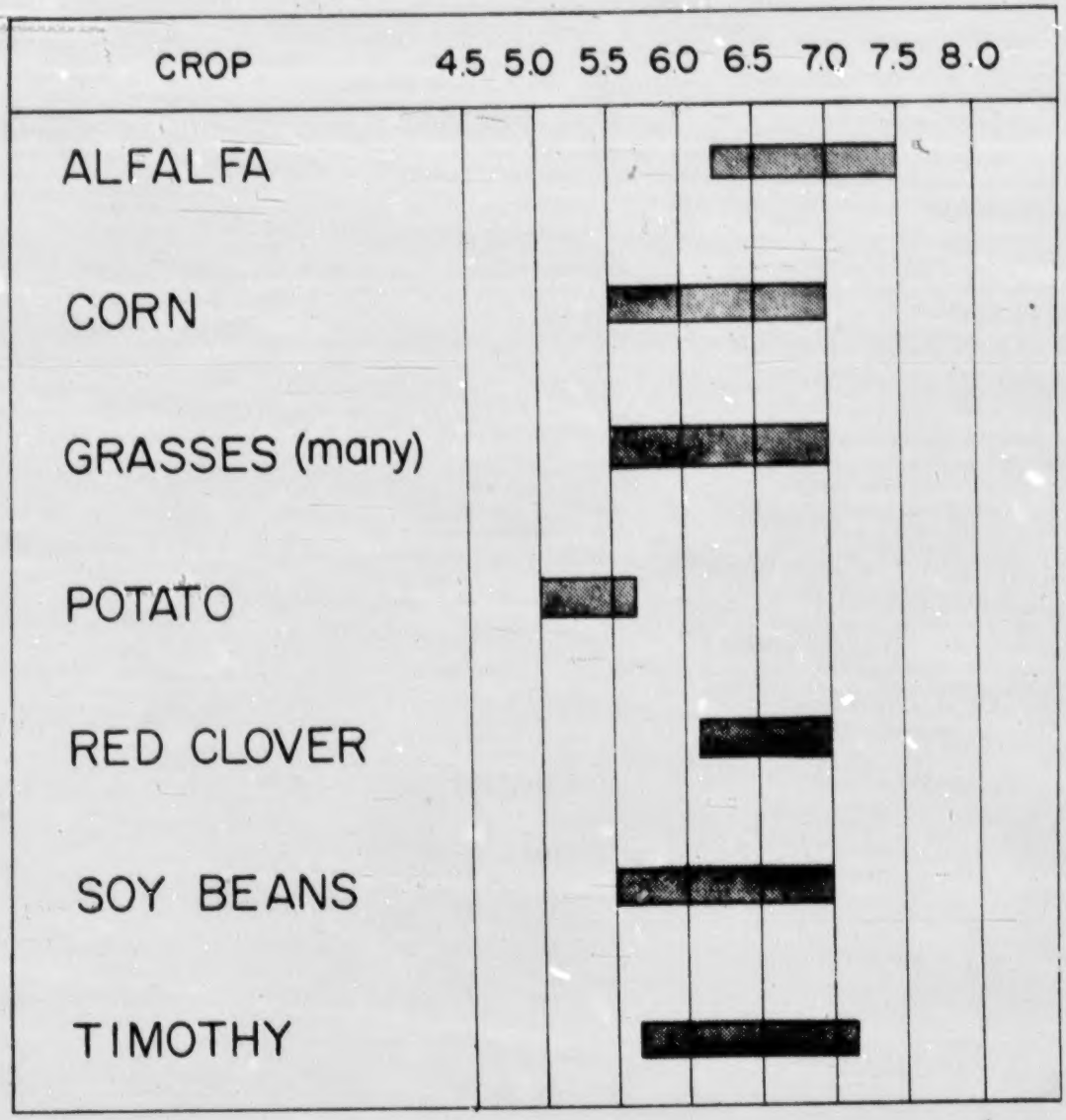
SOIL REACTION AND PLANT NUTRIENT AVAILABILITY

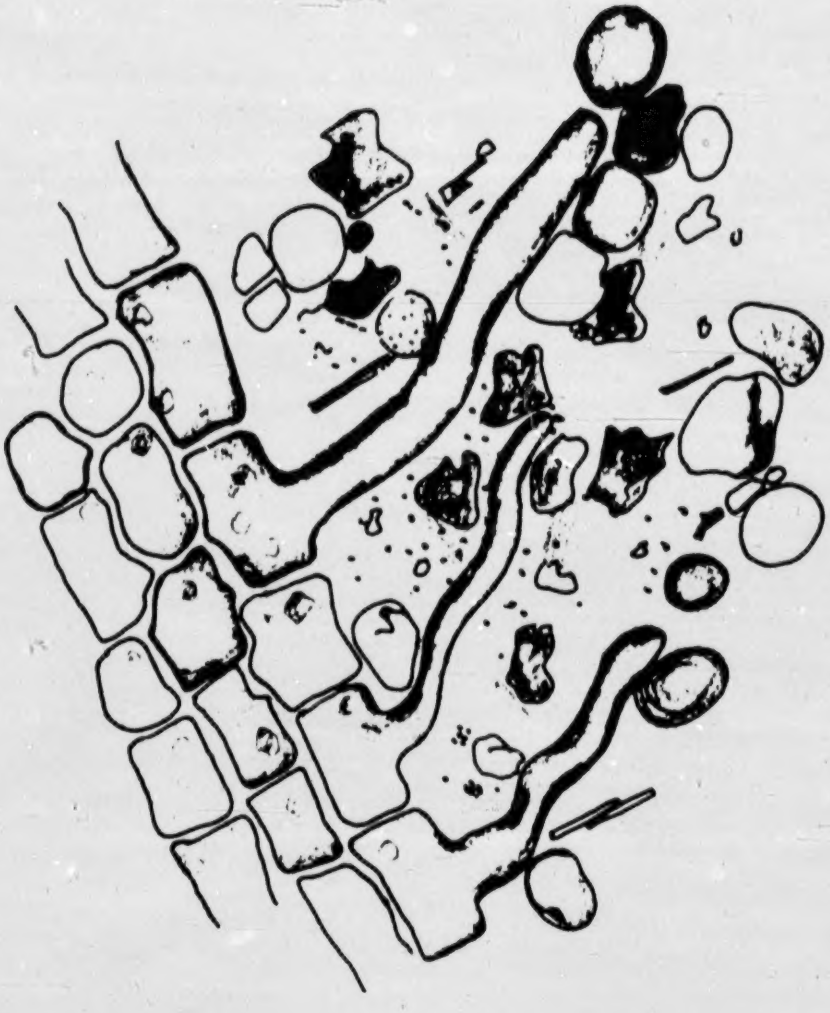



pH SCALE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Neutral
Increasing acidity
Increasing alkalinity

T

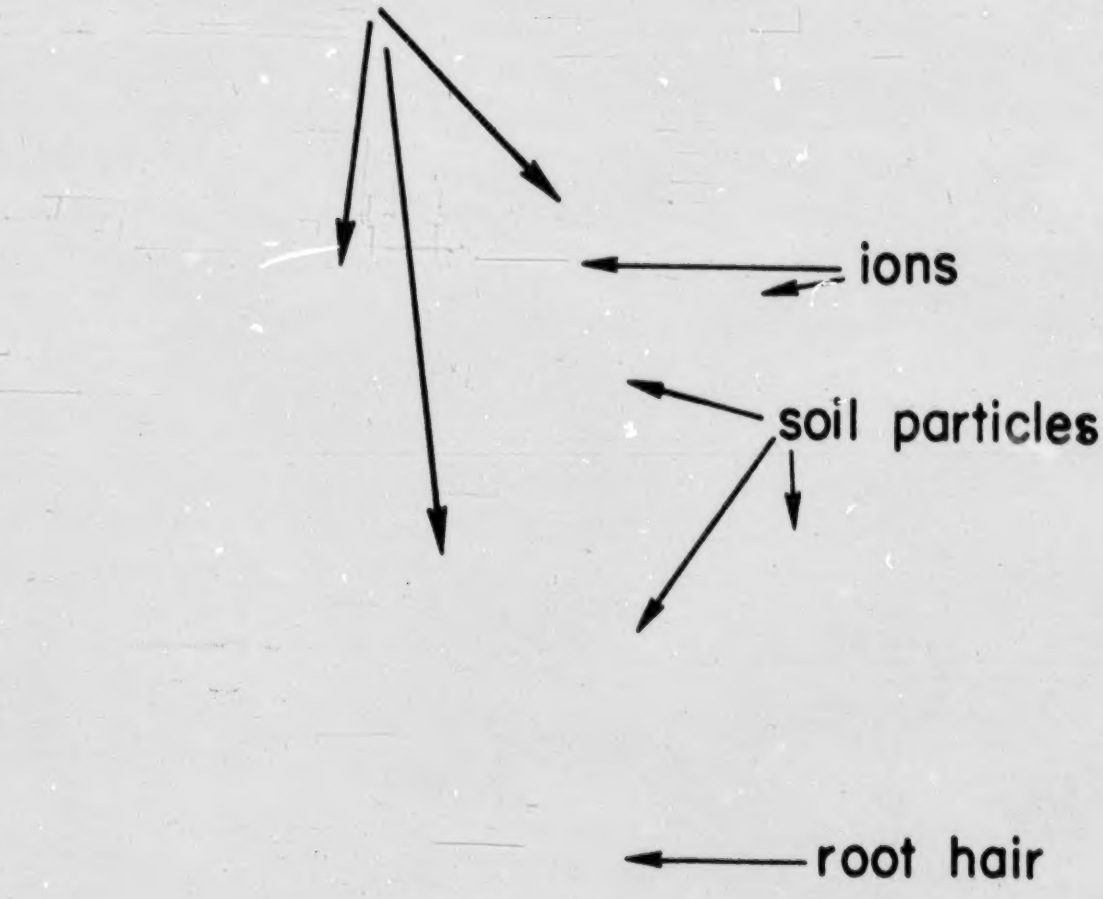
pH REQUIREMENTS OF CROPS

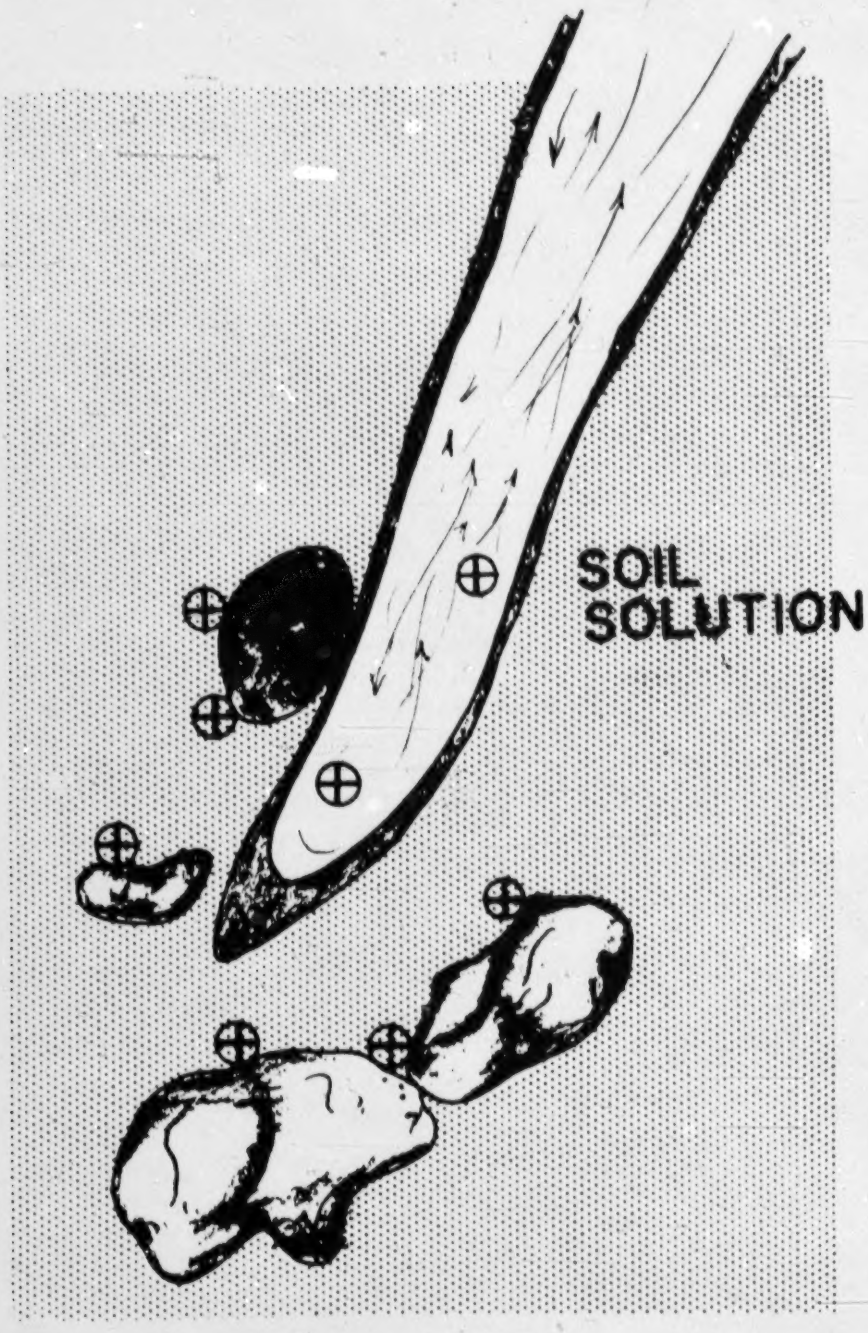




ROOT HAIRS IN SOIL

NH4+
K+
O-
NH4+
K+
O-
Mg++
O-
O-
PO4
Mg++
PO4
NH4+
K+
K+
NH4+
O-
NH4+


nutrient cations
ions
soil particles
root hair

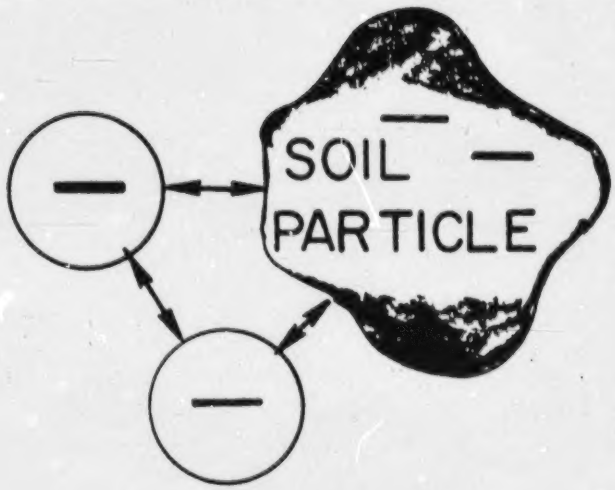

SOIL
SOLUTION

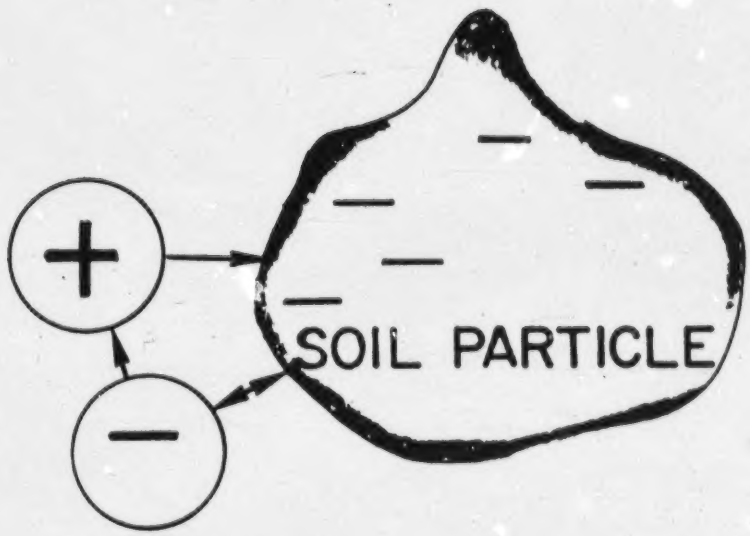
SOIL
SOLUTION

ROOT HAIR

SOIL PARTICLE

CATIONS



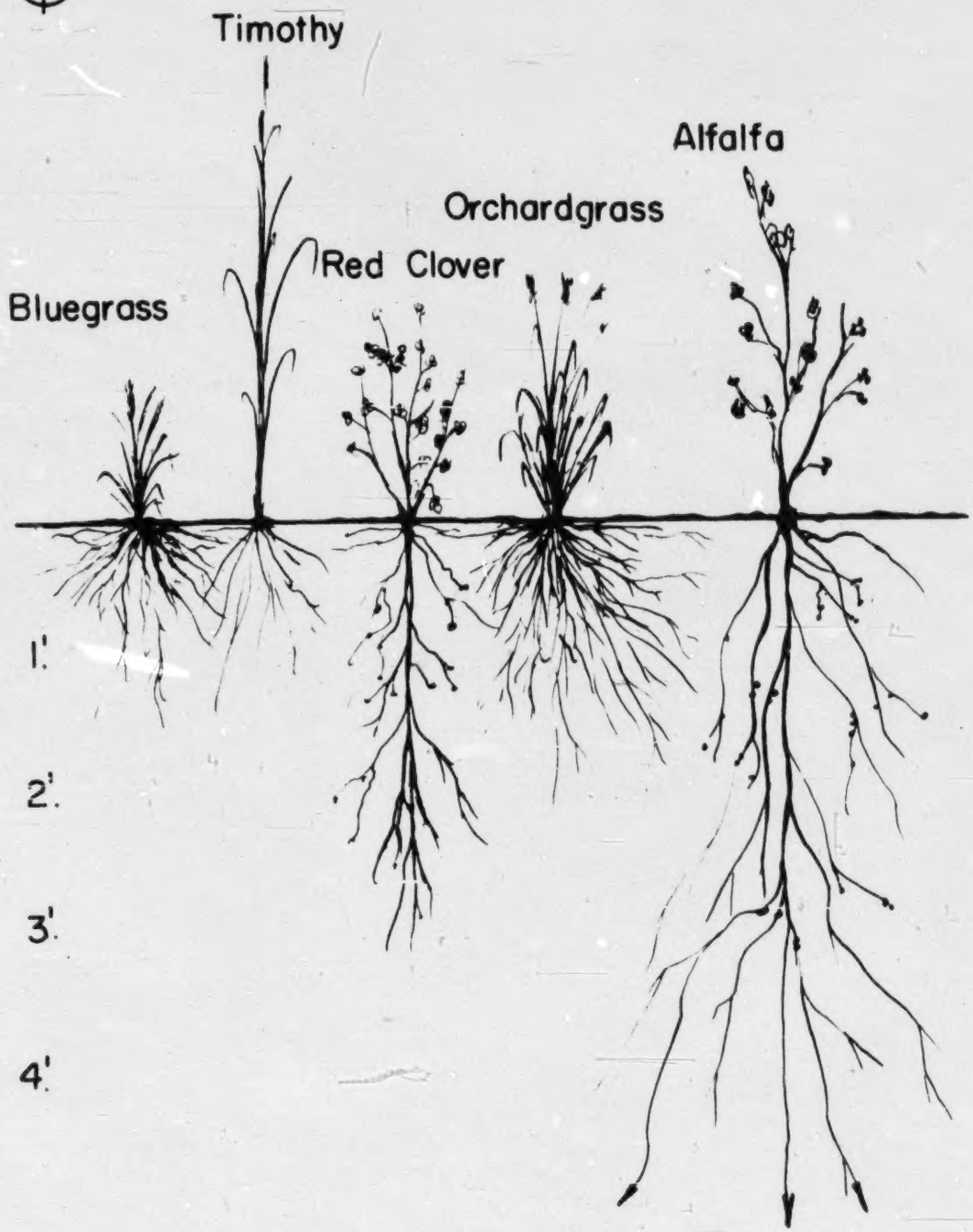


Soil Particles And Ions

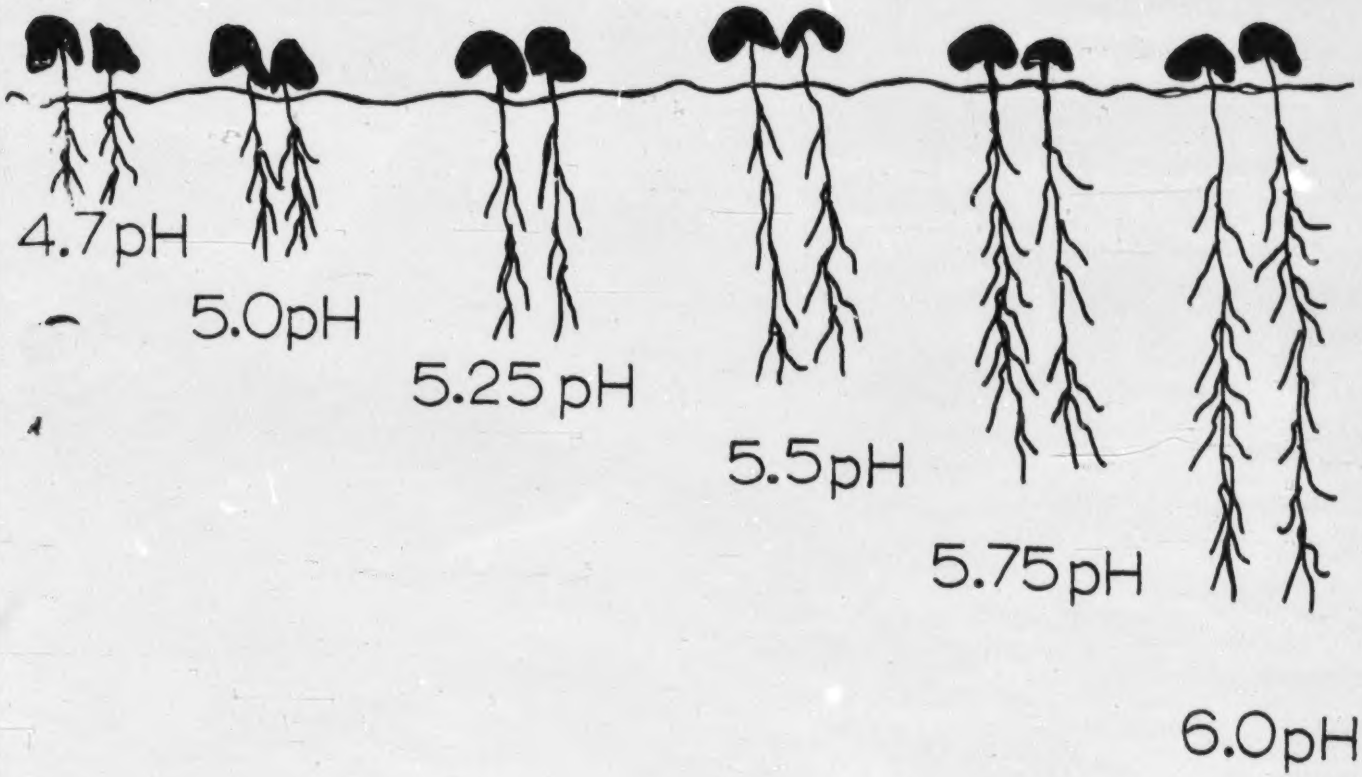
ions and soil particles with like charges repel each other

cation →

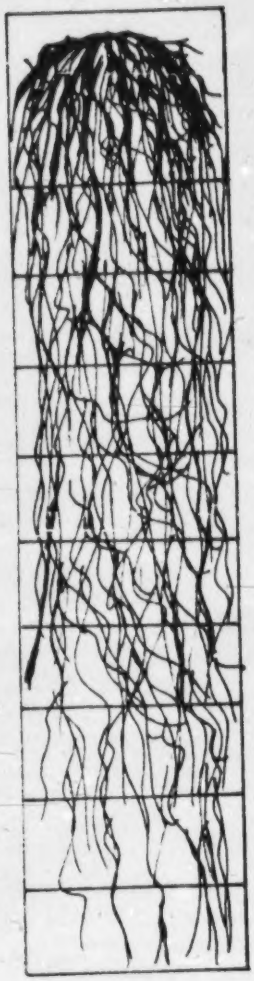
anion →


Timothy
Alfalfa
Orchardgrass
Red Clover
Bluegrass
1'
2'
3'
4'

LOW pH LIMITS
ROOT GROWTH



PROPER SOIL FERTILITY INCREASES ROOT GROWTH



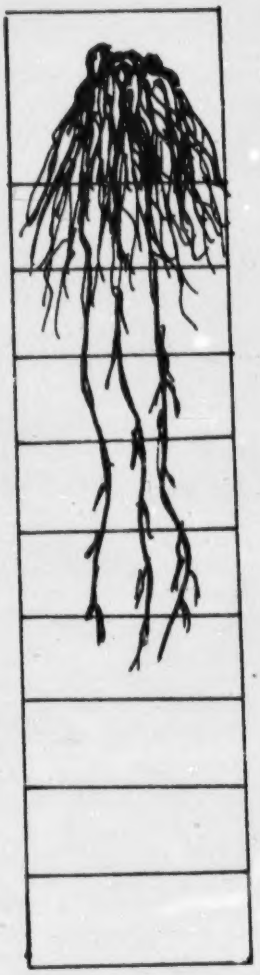
1 Ft.

2 Ft.

3 Ft.

4 Ft.

5 Ft.



Fertilized

Unfertilized

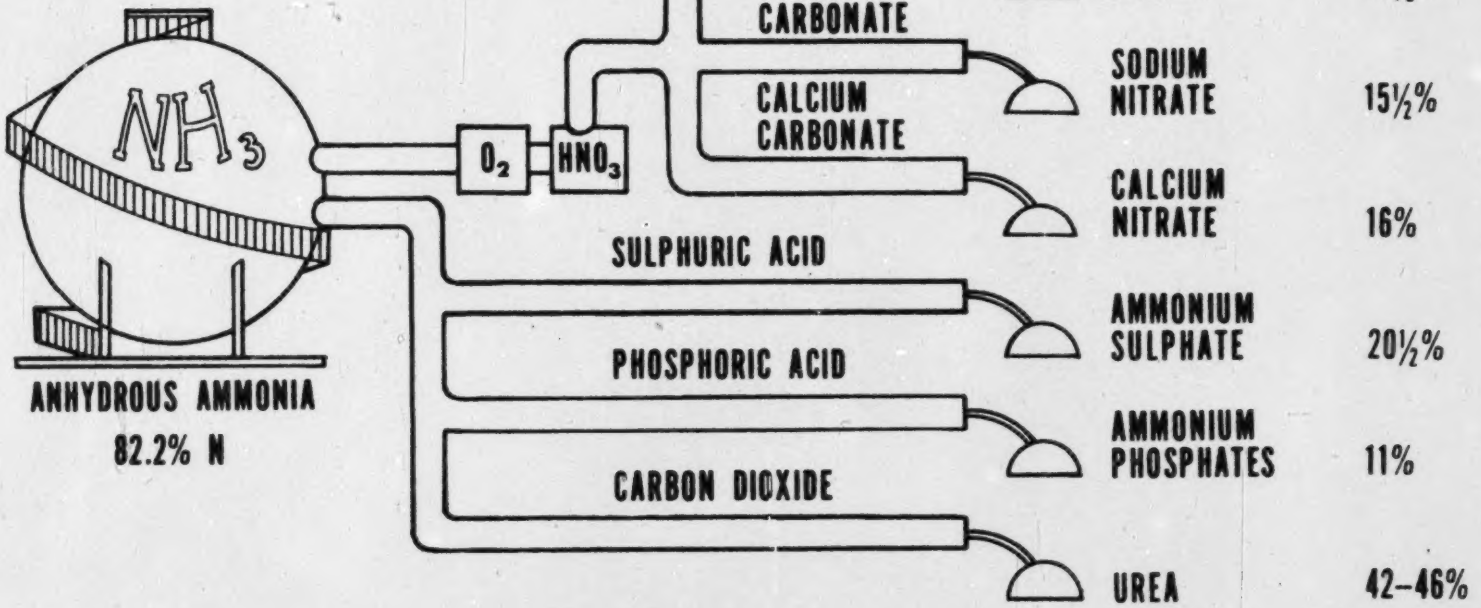
BAND PLACEMENT PAYS OFF IN HIGHER YIELDS OF CORN

INCREASE FROM 200 LBS. 6-24-24

SPLIT BOOT

BAND

NITROGEN FERTILIZER PRODUCTION



FERTILIZER
BAG
N
P
K

PRIMARY PLANT NUTRIENTS

1.

2.

3.

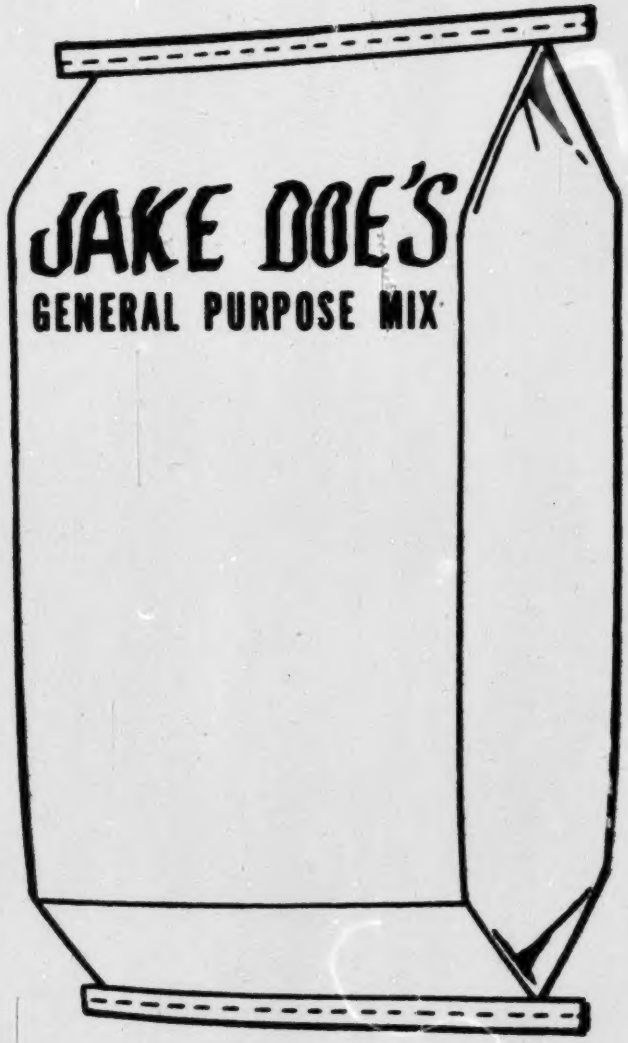
N Nitrogen

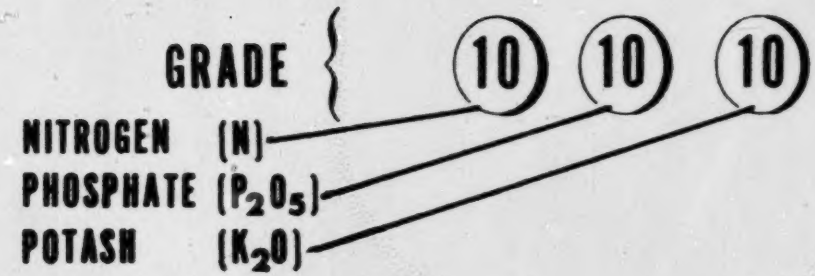
P Phosphorus

K Potassium

FERTILIZER LABELING

MAKER'S BRAND NAME




GRADE
10
10
10
NITROGEN (N)
PHOSPHATE (P_2O_5)
POTASH (K_2O)

ANALYSIS

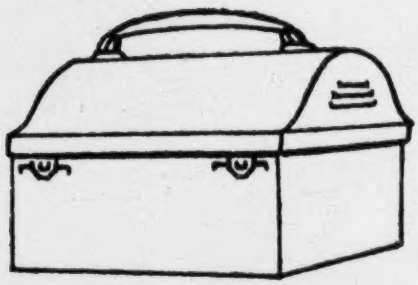
TOTAL NITROGEN.....10%
AVAILABLE PHOSPHORUS.....10%
AVAILABLE POTASH.....10%

LUNCH FOR THE CORN CROP

Purpose: To acquaint the class with fertilizer materials

Materials: A lunch pail, sack, or picnic basket

Procedure: When using fertilizer samples during a fertility discussion, place them in a paper sack marked "lunch", in a picnic basket, or lunch pail. Put the container in an obvious place to arouse the curiosity of the class. At an appropriate time during the discussion take the "corn plant's lunch" (the fertilizer samples) out of the container. Use the fertilizer samples to illustrate your further discussion of feeding the corn plant.



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ELEMENTS ESSENTIAL FOR PLANT GROWTH

Purpose: This demonstration is intended to acquaint the student with the elements needed by plants and where they come from. Knowing plants' needs will help him in selecting and using fertilizer wisely.

The essential elements needed in rather large amounts for plant growth are:

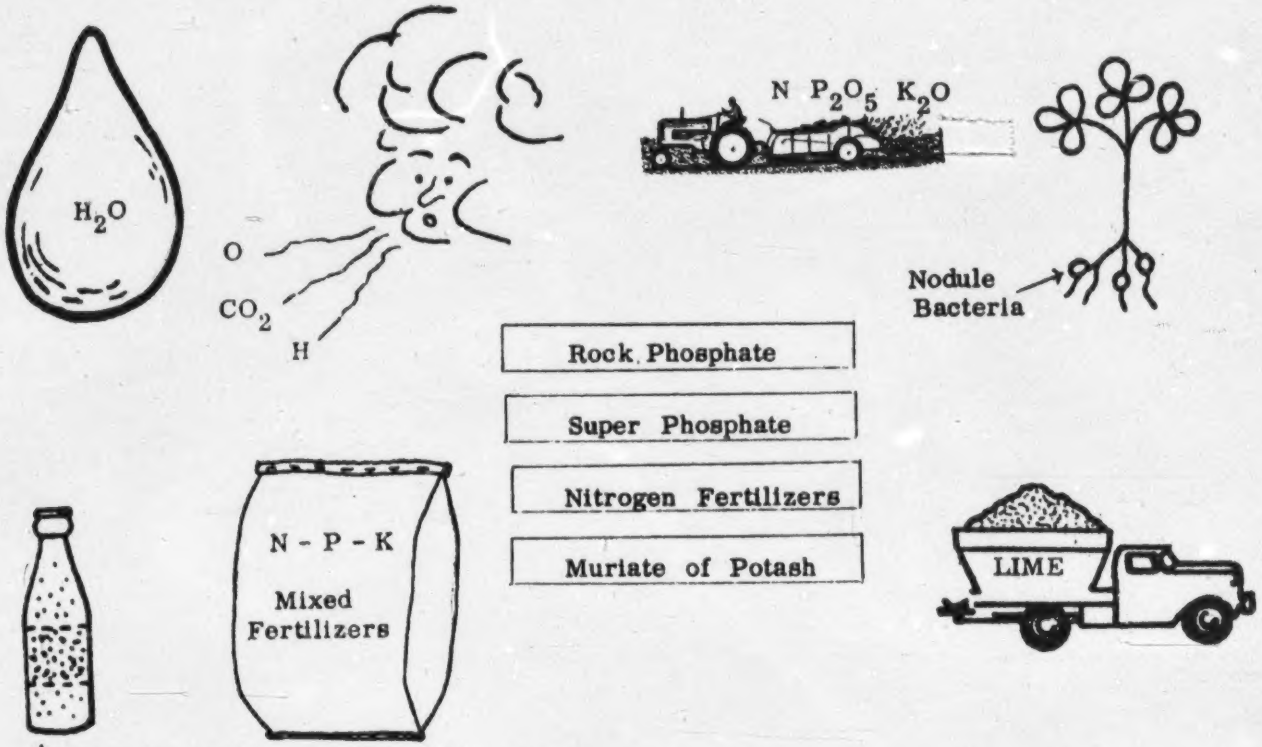
C H O P K N S Ca Mg

Minor elements which are also essential are: Mn Zn Cu Mo B Cl. Green plants also contain Na and Co which are essential to animals but not to plants.

Materials: Flannelboard or suede-paper materials as illustrated.

Procedure: Place each chemical symbol on the flannelboard as it is discussed.

Where do these elements come from? Use symbols or models to illustrate sources of the elements needed for plant growth.



Bottle of soda pop may be used to show CO_2

Other illustrations may be added to those shown above.

References - 1957 USDA Yearbook - Soil, page 80
FARM SOILS, E. L. Worthen and S. R. Aldrich, Wiley & Sons, 1956, pp. 122

BALANCED FERTILITY

Purpose: The purpose of this demonstration is to show that if one or more of the major plant-food elements is deficient in the soil, plants can not attain maximum growth.

Materials:

[N] [N] [N]
3 green blocks representing nitrogen

[P] [P]
2 blue blocks representing phosphorus

[K] [K] [K] [K] [K]
5 orange blocks representing potassium

Procedure: Build the blocks one on top of the other to represent a plant, alternating the colors. Use a green (N) block first, then a blue one (P), then an orange one (K). Repeat this a second time and start a third time, but you will run out of blue blocks and cannot proceed even though you have some orange (K) blocks left. How could you increase the height of your pile or the growth of a plant? Could you do it by adding more blue blocks (P)?

Magnets may be inserted in the back of the blocks if you wish to use this demonstration on a magnetboard or colored paper squares can be used on a flannelboard.

h

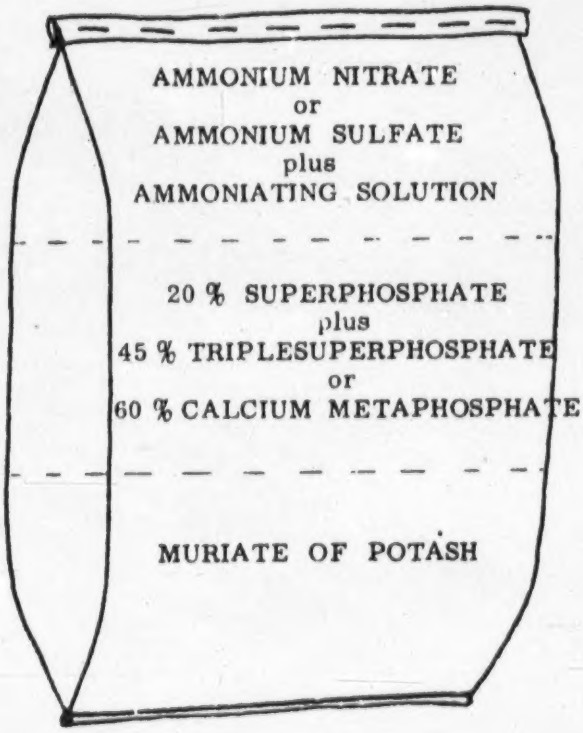
WHAT'S IN THE FERTILIZER BAG?

Purpose: The purpose of this demonstration is to acquaint the student with the composition of commercial fertilizer.

Materials: 3 parts of fertilizer bag
3 signs

Procedure: Use flannelboard materials to illustrate what a bag of fertilizer contains.

Example: 100 pounds of 5-20-20 can be made up of materials indicated inside the bag. There are many other ways to make this same analysis involving other fertilizer materials to supply these nutrients.



SUPPLIES 5 lbs. of N

SUPPLIES 20 lbs. of P_2O_5

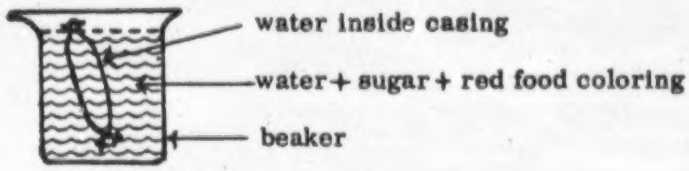
SUPPLIES 20 lbs. of K_2O

NATURE OF FERTILIZER "BURN" AND FERTILIZER PLACEMENT

Purpose: Fertilizer injury may prevent germination, or "burn" the roots of young seedlings and cause sickly young plants. Fertilizer "burn" is caused by a strong salt solution around the germinating seed or young plant roots. High concentrations of fertilizer near plant roots may cause the sap to move out of the plant and the plant to wilt and die for lack of moisture even in a moist soil! This demonstration is designed to illustrate what may happen when fertilizer is used in excess or is not properly placed.

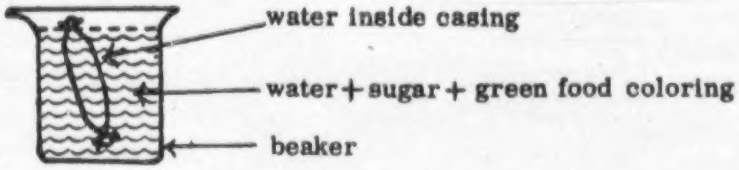
Materials: 2 large beakers or jars of water
2 4- or 5-inch lengths of Visking cellulose casing
1 set of food dyes
Sugar
Thread

Procedure: Fill a beaker with a solution of one part of sugar to about two parts of water. Tie a knot in one end of the cellulose casing and fill the casing with ordinary water. The water in the beaker may be colored with red food coloring to make the demonstration more effective. Tie a string or thread around the other end of the casing in such a way that the casing is fully expanded and there is no air space inside. Place the casing in the sugar solution.



What to look for: Observe the demonstration after about one hour and note how the water has been "pulled" out of the casing, causing it to "wilt".

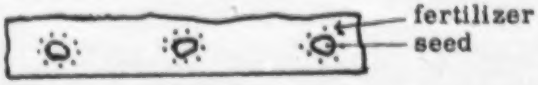
What else to do: To make the demonstration even more effective set up another beaker similar to the one described but use water with green food coloring inside the beaker and do not add sugar.



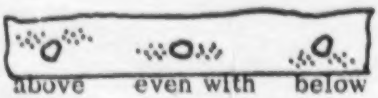
This illustrates a healthy plant root which does not "wilt".

Flannelgraph or chalkboard materials may be used to supplement this demonstration with a discussion on fertilizer placement.

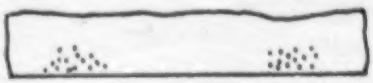
Drilled in contact with the seed



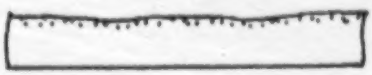
Drilled slightly to the side of the seed



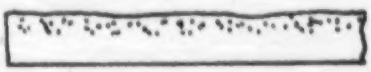
On the plow sole



Broadcast on the surface

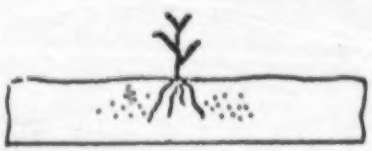


Broadcast on the surface and harrowed in



Broadcast and plowed under

Sidedressed



Reference: FARM SOILS, Worthen and Aldrich, Wiley & Sons, 1956, pp 164-167

H

DOES NITROGEN LEACH FROM THE SOIL?

Purpose: Nitrogen is supplied in many fertilizers either as the positively charged NH_4^+ form or as the negatively charged NO_3^- form. Although nitrogen may be changed into various forms in the soil, it is sometimes advantageous to consider which form is most subject to leaching--especially if the nitrogen is to be applied in the fall.

Since soil particles generally carry negative charges, the positively charged NH_4^+ form clings to them better than does the negatively charged NO_3^- form. This demonstration shows how positively charged particles such as NH_4^+ can be held in the soil while negatively charged forms such as NO_3^- can leach out. Both may be leached from very coarse-textured soils.

Materials:
- 3 plexiglass tubes
- 1 pint fine quartz sand
- 1/2 pint very coarse sand
- 1 packet gentian violet dye
- 1 packet eosin dye
- 2 pint bottles
- 3 ring stands
- 3 clampholders
- 3 clamps
- 3 containers to catch water
- Flannelboard illustrations of clay, NH_4^+ and NO_3^-

Procedure:

1. Fill two plastic permeability tubes each 1/2 full of fine quartz sand and mount on a ring stand.

2 Place a clear glass container beneath each tube to catch solution that runs through.

3. Mix a very small pinch of positively charged purple dye (gentian violet) in a pint of water and pour about half of it in one of the tubes. *

4. Mix a very small pinch of negatively charged red dye (eosin) in a pint of water and pour about half of it in the other tube.

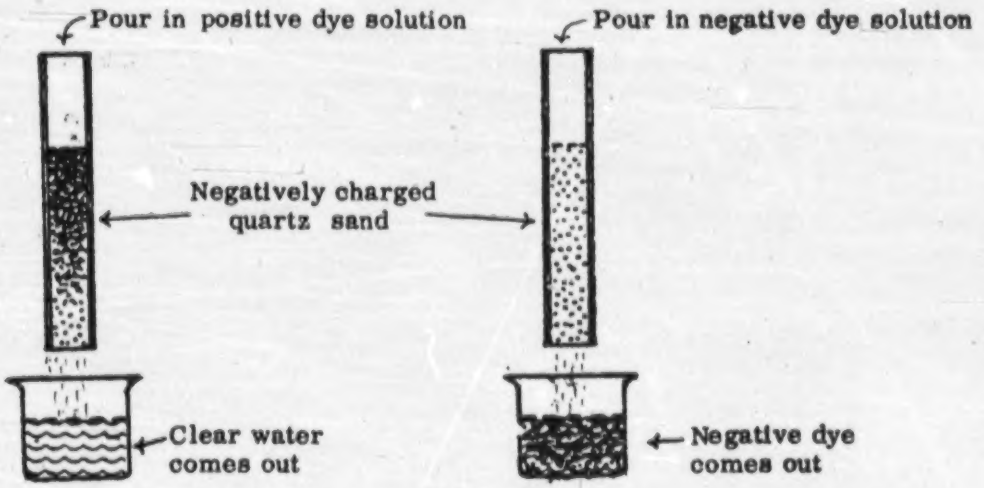
Note that the positively charged particles of purple dye are held on the negatively charged quartz sand particles and hence the water that passes through is clear. (Try not to put in so much purple dye that it runs through, but in case you accidentally do pour in too much you can call this overfertilization.) The negatively charged particles of the red dye do not cling to the negatively charged sand and pass through with the water.

5. Now mix the remaining 1/2 pint of red dye with the remaining 1/2 pint of purple dye. Pour half of the mixture in the tube which you just poured the red dye through. Note that the purple dye is held on the particles but the red dye passes through. This represents a fertilizer such as NH_4NO_3.

* A 0.1 percent stock solution of gentian violet and a 0.5 percent stock solution of eosin may be made from the powdered dyes and water. Dilute 5 ml. of the stock solution to 500 ml. (or approximately one pint) for the demonstration.
Use extreme caution with dyes as they can be quite "messy." It is suggested that only the teacher handle the powdered dyes. Be careful not to get dyes on any surface or materials which might be stained.

6. Now mount a third plastic permeability tube containing very coarse sand particles. Pour your remaining mixture of red and purple dye solution in it. Note that coarse particles do not have the ability to hold either the positively charged or the negatively charged particles of dye. This illustrates that nitrogen fertilizers may be more easily leached from coarse textured soils such as sandy soils. Would you put as much fertilizer on coarse textured soils as you would on fine textured soil at one time? Would you fertilize coarse textured soils more often than fine textured soils?

7. You can supplement your discussion with flannelboard illustrations of a clay particle, NH_4^+ ions and NO_3^- ions.



Note: A very permeable soil may be substituted for the quartz sand. Be sure to try this before you demonstrate it to a group.

SOIL ACIDITY AND LIMING AS INFLUENCED BY KIND OF SOIL

Purpose: This demonstration is intended to show that coarse textured soils and those with little organic matter do not need as much limestone to correct acidity as do fine textured soils or those high in organic matter. Sandy soils, because of their lower clay and humus content, have fewer reactive spots where exchangeable hydrogen (the acidity factor in soils) can be held and, accordingly, lower exchange capacities than fine textured soils.

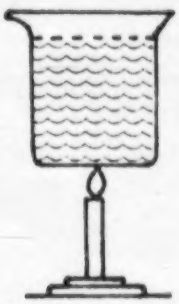
An analogy is made between the amount of heat needed to raise the temperature of different amounts of water and the amount of limestone needed to raise the pH of different soils.

Materials:
- 2 high temperature thermometers
- 2 large beakers
- 2 bunsen burners or other sources of heat
- Clay and sand particles for flannelboard
- "H" blocks for flannelboard

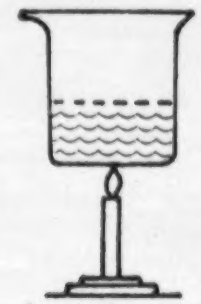
Procedure: Fill one beaker almost full of water. Fill the other beaker about 1/4 full of water.

Adjust the flame the same on each of two bunsen burners and place under the two beakers.

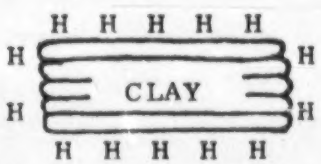
Place the thermometers in the beakers and note the time it takes for each thermometer to rise a given amount, i.e. to 150°.



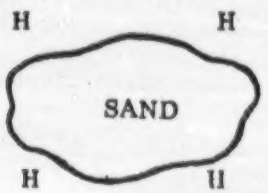
More water to heat - Therefore more heat needed to raise the temperature to 150°



Less water to heat - Therefore less heat needed to raise the temperature to 150°



More H needs replacing. Therefore more Ca from limestone is needed to raise pH to 7.

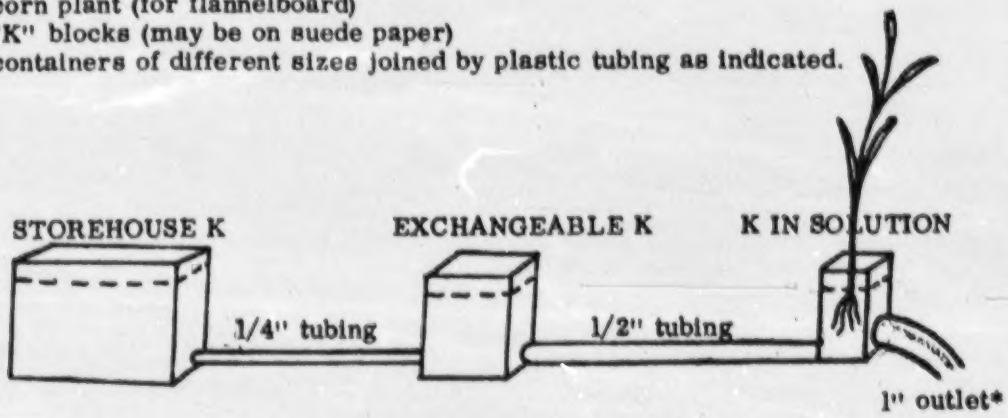


Less H needs replacing. Therefore less Ca from limestone is needed to raise pH to 7.

THE NATURE OF POTASSIUM IN SOIL

Purpose: To develop an understanding of the various forms of potassium in the soil as a basis for interpreting soil tests and making wise use of potassium fertilizers.

Materials: 2 clay particles (for flannelboard)
1 corn plant (for flannelboard)
6 "K" blocks (may be on suede paper)
3 containers of different sizes joined by plastic tubing as indicated.



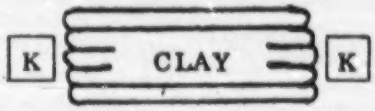
Procedure: Fill all three tanks and open the outlet. (Use water.)

What to look for: The water in the tanks represents the K in the soil. Note that the outlet, which is analogous to a plant drawing K from the soil solution, draws the water out of the smaller tanks faster than it can be supplied from the larger tank, but if the outlet is closed the supply in the smaller tanks will build up if there is sufficient water in the large tank.

What else to do: Pour water in the smallest tank while the larger tanks are relatively empty and the outlet is closed. The water moves from the smaller tank to build up the supply of water in the larger tanks. This is analogous to adding potassium fertilizer.

Explanation: Potassium occurs in the soil in three main forms: (1) in the soil solution, (2) as exchangeable K, and (3) in the storehouse form. The K in the soil solution is used by plants. The exchangeable K is held on the outside of the clay minerals and the soil humus; the storehouse form of K is held in the interior of the clay. You can use flannelboard materials or drawings to illustrate this.

STOREHOUSE FORM
(held inside the clay)



EXCHANGEABLE FORM
(held on the outside of the clay)

K IN THE SOIL SOLUTION

* A piece of rubber tubing connected to an aspirator may be used in place of the outlet to draw the water out of the smallest tank.

As K in the soil solution is used by plants, the exchangeable K on the clay goes into the solution and in turn the K from inside the clay (storehouse form) moves to the outside of the clay thus becoming exchangeable. During the time of the year when crops are not growing, K continues to move from the storehouse to build up the supply of exchangeable and soil solution K.

As plants remove K from the soil solution, exchangeable K goes into the soil solution and thus the amount of exchangeable K is reduced. In turn, K will move out slowly from the storehouse to the exchangeable form - if the storehouse is well filled.

Soil tests measure the potassium in solution plus the exchangeable (available) potassium.

Potash fertilizers are water soluble. When added to the soil, they first dissolve in the soil solution and then may go onto or into the clay particles where they are held relatively safe from leaching - either in the storehouse form or as exchangeable K.

Because of the storehouse phenomena, the same soil test value for available K may have different long-range interpretations. On the dark-colored soils where the storehouse is still fairly well filled, a 180-pound test, for example, may be an adequate value for most crops and, because of renewal from the storehouse, will not decrease rapidly.

But a 180-pound test on a light-colored clay-pan soil in southern Illinois does not mean the same thing. These untreated soils almost always have very little K in the storehouse. A 180-pound value may mean that potash has recently been supplied and little of it has yet gone into the storehouse. Or it may mean that the continuous use of K has built up both the storehouse supply and the exchangeable potassium supply.

This means that the 180-pound test value can be interpreted in three different ways:

1. On a dark-colored silt or clay loam soil in central or northern Illinois, where the storehouse is large and fairly well filled, it means that K is not now deficient, will not become seriously deficient over the next few years, need not be returned in an amount equal to that removed in crops, and is required in only a small amount in drilled or hill-dropped fertilizers for balance and starter effect.

2. On the highly weathered, originally highly acid and potash-deficient soils of southern Illinois (for example the light-colored clay-pan soils) that have had previous treatment with K extending over 10 to 15 years, this test value means that the storehouse has been at least partly renewed and that only maintenance amounts should be used to keep the level adequate.

3. On the same kind of soils as are described in (2) above, but which had only one or two recent treatments with potash, then this test value should be regarded as showing sufficient K for that year only. Any recommendations for future treatments should be made on the basis that the soil is deficient in potash.

References:

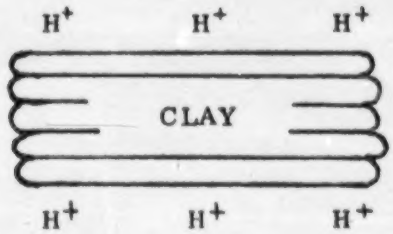
Farm Soils, Worthen and Aldrich, Wiley and Sons 1956, pp 140.

THE NATURE OF SOIL ACIDITY

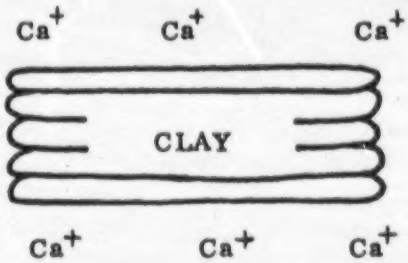
Purpose: To develop an understanding of the chemical nature of soil acidity and the effect of adding limestone.

Materials:
1 clay particle for flannelboard
1 limestone truck for flannelboard
6 "H" blocks for flannelboard
6 "Ca" blocks for flannelboard

Procedure: Use flannelboard materials to illustrate a clay particle in an acid soil.



Point out that adding limestone will make the soil less acid; because the hydrogen ions around the clay particle are replaced by calcium ions:



THE MANUFACTURE OF PHOSPHATE FERTILIZERS

Purposes: 1. To develop an understanding of the chemical manufacture of superphosphate and other phosphate fertilizers.

2. To develop an understanding of the differences between rock phosphate and superphosphate.

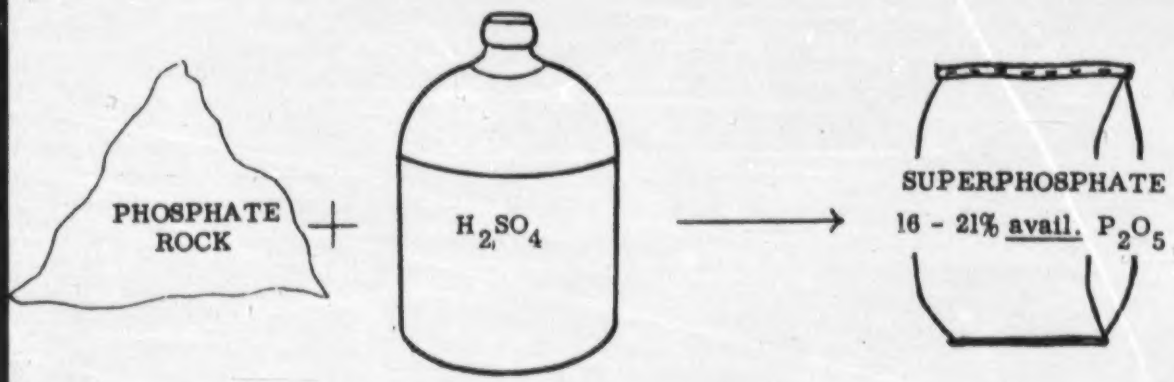
Materials: 100 grams finely ground rock phosphate

41 mls. concentrated sulphuric acid (H_2SO_4)
25 mls. water
100 ml. beaker
600 ml. beaker
Stirring rod
Flannelboard materials as illustrated

Procedure for Making Superphosphate: Dilute the acid with the water in the 100 ml. beaker. (Be careful when mixing sulphuric acid and water. ALWAYS ADD THE ACID TO THE WATER, POURING THE ACID SLOWLY DOWN THE SIDE OF THE CONTAINER.) Place the 100 grams of finely ground rock phosphate in the 600 ml. beaker and add the diluted acid--stirring slowly. Do this near an open window or other well ventilated place, since some fluorine and other gases are given off by the reaction. The material will remain in a slurry form for a few minutes and then it will begin to set up or harden.

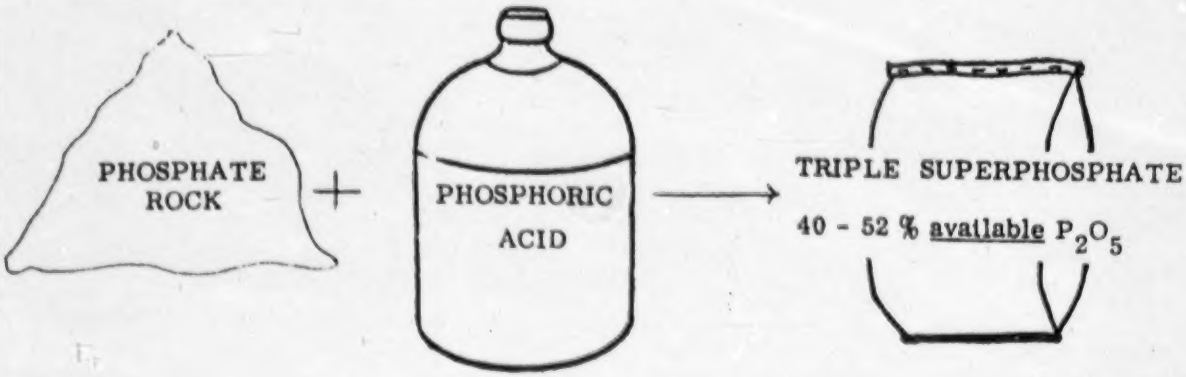
Explanation:

Superphosphate is made by treating phosphate rock with sulfuric acid:



Phosphate rock + H_2SO_4 ⟶ Water soluble P_2O_5 + Citrate soluble P_2O_5 + $CaSO_4$ (Gypsum) + Impurities

Triple superphosphate is made by treating a high grade phosphate rock with phosphoric acid:



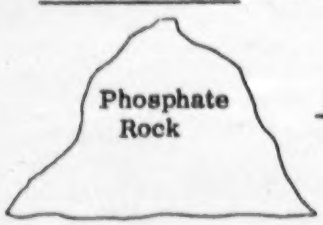
Phosphate rock + Phosphoric acid ⟶ Water soluble P_2O_5 + Impurities

Calcium metaphosphate is made by first obtaining elemental phosphorus by heating phosphate rock in an electric furnace and then burning this to P_2O_5 in the presence of finely ground rock:

Step 1. Phosphate rock in electric furnace ⟶ Phosphorus

Step 2. Phosphorus + oxygen + phosphate rock ⟶ Calcium metaphosphate
60 to 62% available P_2O_5

Rock phosphate is made by grinding phosphate rock:



\+ Very fine grinding ⟶ Rock Phosphate
30 to 36% total P_2O_5 of which about 1/10 (3 to 4% of total weight) is classed as immediately "available" (see below)

Phosphorus in fertilizers is indicated as "available P_2O_5" which is defined as P_2O_5 that is water soluble plus that which is soluble in ammonium citrate. Both water soluble and "citrate soluble" P_2O_5 are "available" to plants.

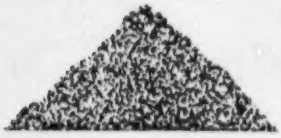
TEST DON'T GUESS

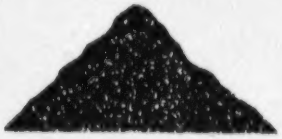
Purpose: To demonstrate that you can't determine the fertility of a soil by merely looking at it.

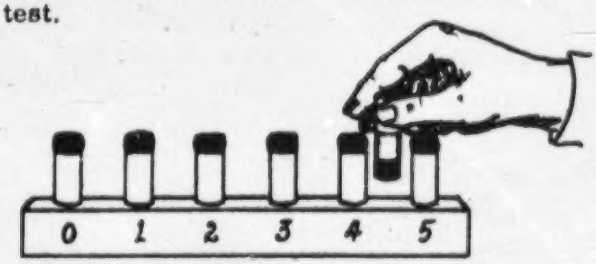
Materials:

1. A sample of light colored soil testing high in pH, phosphorus, and potassium.
2. A sample of dark colored soil testing low in pH, phosphorus, and potassium.
3. Soil testing equipment.

Procedure: Display the light and dark soil samples before the class and ask them which is most fertile. Have them check their answers by testing the soils. Part of the class will likely guess the dark soil to be most fertile but, if the samples have been carefully selected and pretested, this demonstration can show that you can not always guess how fertile a soil is by looking at it. It is best to test.







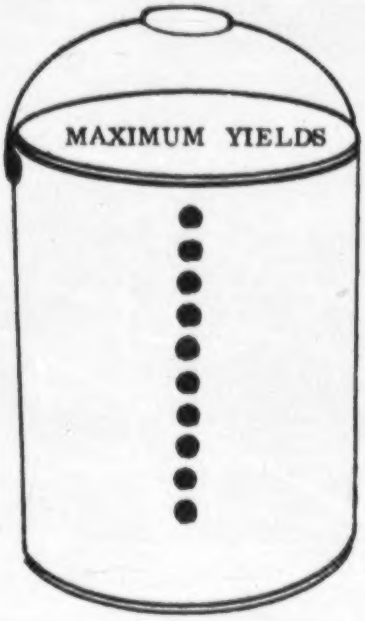
Explanation: This demonstration shows that it is not possible to predict the pH, phosphorus, and potassium content of Illinois soils merely by looking at them. The color does, however, nearly always indicate the organic-matter content and nitrogen content of Illinois soils.

A BARREL FULL OF LEARNING

Purpose: To add "punch" to your class meeting.

Materials: A 5 gallon bucket, nail keg, or barrel
10 corks
10 signs
10 magnets (optional)

Procedure: Drill holes in a nail keg, barrel, or 5 gallon bucket as indicated. At the beginning of the class period or as the period progresses fill the holes with corks representing the phases of study or representing approved practices discussed.



Soil Tilth
Organic Matter
Nitrogen
Legumes
Drainage
Contouring
Soil Tests
Limestone
Phosphorus
Potassium

Signs may be attached to the corks, painted on the container, displayed separately, or backed with magnets if a metal container is used.

The container may also serve as a container to receive written questions or comments from class members.